Introduction to Environmental Geology, 5e

Chapter 19

Geology, Society, and the Future

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Chapter 19: Overview

- Know geologic aspects of environmental health.
- Understand the geologist's role in evaluating land for appropriate uses.
- Understand environmental impact analysis.
- Know the process of law; the use of mediation and negotiation to solve environmental conflicts.
- Be able to discuss what steps are necessary to attain the goal of sustainability.

Case History
Radon Gas: The Stanley Watrus Story

- In December of 1984, scientists discovered that radon (a radioactive gas) from soil and rock may enter the home and possibly present a serious health hazard
- Stanley Watras lived in Boyertown, PA, the radiation level of the indoor air at his house was 3,200 pCi/l, 800 times higher than the level of 4 pCi/l, a threshold set by the EPA
- Held the highest record in early 1980s, until a home in Whispering Hills, New Jersey, reached a radiation level of 3,500 pCi/l
- Increased awareness of the radon gas problem in the United States since 1985

Environmental Geology and Society

Overall challenges:

- How to balance between economic development and environmental sustainability
- How to form an ecological equilibrium by meeting the needs of a society
- Ultimate goal for the future: creating a harmonious state between the general environment and human society

Geology and Environmental Health

- Disease: an imbalance from poor adjustment of an individual to the environment
- Environmental toxin and toxicology: study of poisons/toxins and potential effects on people and ecosystems, as well as associated clinical, economic, industrial, and legal problems
- Carcinogen: toxin that causes cancer
- Disastrous effects from minute amount of toxin measured in ppm, ppb, mg/L, or pCi/L (radioactive toxin)

Lead in the Environment

- Lead poisoning: geologic, cultural, political, and economical factors involved
- Effects: anemia, mental retardation, palsy, and even behavioral problems
- Sources: in past used in gasoline, paints, some moonshine whiskey, and other products
- Widespread lead poisoning suggested for the reason behind the fall of the Roman Empire

Geologic Factors of Environmental Health

- Soil: Foundation for agriculture, homes, and industries
- Water: Used for drinking, agriculture, and industries
- Air: Indispensable for life
- “Natural” or “virgin” or “pure” environment not necessarily good as widely perceived
- Human activities: Detrimental or beneficial processes for the environmental quality

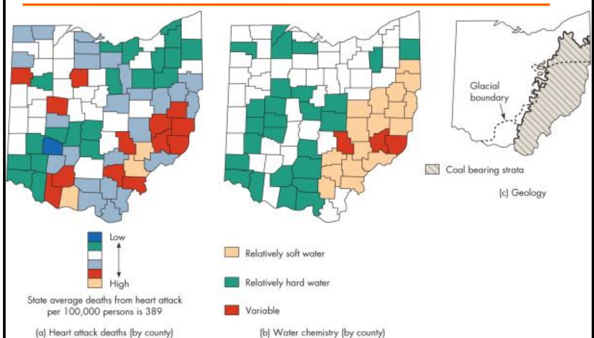
Chronic Disease and the Geologic Environment

- Geologic processes: operate on geologic time
- Diseases: occur and measured on biologic time
- Regional and local variations in chronic diseases
- Challenges: cause-and-effect hypothesis not specific enough, difficulties in obtaining reliable and comparable data, hard to differentiate environmental causes vs. genetic factors

Heart Disease and the Geologic Environment

- Heart disease: coronary heart disease and cardiovascular disease
- Possible link between water chemistry and heart disease
- Higher rate of heart disease in communities with relatively soft water, based on studies in Japan, England, Wales, Sweden, and the U.S.
  - Soft water is more acidic than hard water.
- Uncertain relationships between water hardness and heart disease

Heart Disease and the Water



Cancer and the Geochemical Environment

Carcinogenic materials: carcinogenic substances arise from natural and anthropogenic sources

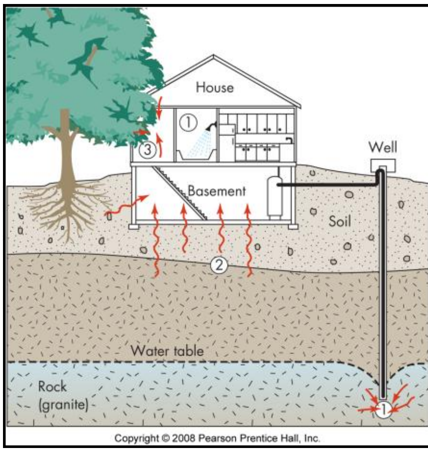
- Naturally occurring in air (radon gas), soil, water
- Human activities: industrial products and processes
- Industrial waste: threats to water and air quality
- Potential problems with present water treatment using chlorine

Radon Gas

- Colorless, odorless, and tasteless
- Released from uranium-bearing rocks
- Exposure to radon gas of elevated concentration leading to higher risk of lung cancer, EPA estimated lung cancer deaths related to exposure to radon gas (7k-30k deaths are related)
- Exposure to both radon gas and tobacco 10 times as hazardous as exposure to one alone
- No definitive conclusion on cause-and-effect relationship between lung cancer and radon gas

Geology of Radon Gas

- The actual amount of radon that reaches the surface of the Earth is related to the concentration of uranium in the rock and soil
- Some regions of the United States contain bedrock with an above-average natural concentration of uranium, PA, NJ, and NY etc.
- Geologic structures, such as shear zones, fracture zones, and faults, commonly enriched with uranium
- The amount of radon gas, escaping from bedrock and soil particles, influenced by water content.
- Movement of radon gas from fractures in rock and pore spaces in soil facilitated by relatively low moisture content



Radon Gas in the Home

Figure 19.C

Reducing Concentrations of Radon

- Improve home ventilation
- Locate and stop the entry point of radon gas to homes or buildings
- Construct a venting system
- Recognizing the whole picture and knowing that the problem is solvable

Air Pollution: Geologic Perspective

- Pollutants in the atmosphere → pollutants in the hydrologic and geochemical cycles
- Air pollution: Serious health hazard in many large cities
- Effects on human artifacts: Effects of air pollution on buildings and monuments
- Aesthetic effects: Reducing visual range and atmospheric clarity

Sources of Air Pollution

- Stationary
  - Point sources: Discreet and defined location, such as power plant
  - Fugitive sources: From an open area such as construction site, farmland
  - Area sources: Several sources within a well-defined area, such as an urban area
- Mobile
  - Moving sources, such as automobiles, aircrafts

Air Pollutants

- Physical state
  - Gaseous form: SO_2, NO_x , CO, O_3, volatile organic compounds (VOCs)
  - Solid or liquid form: Particulates, PM 10 (less than 10 µm or PM 2.5 (less than 2.5 µm)
- Air Toxins: Pollutants causing cancer or other serious health problems
- Pathway to air
  - Primary pollutants: Emitted directly into the air
  - Secondary pollutants: From the reactions of primary pollutants with atmospheric compounds

Particulate Matter

- PM 2.5 and PM 10: Diameters less than 2.5 µm and 10 µm respectively
- 90 percent particulates from natural resources
- Sources: Desertification, volcanic eruption, fire, and farm lands
- Industrial sources: Asbestos dust and heavy metals (As, Cu, Pb, Zn)

Urban Air Pollution

- Air pollution not distributed uniformly, mostly concentrated around urban areas
- Sources of pollution: In and around urban areas such as automobiles, industry emission
- Form of air pollution: Urban smog
- Affected by meteorology and topography

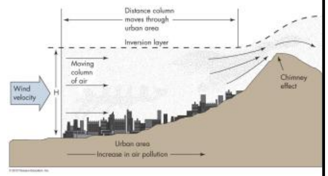


Figure 19.4

Influence Factors in Urban Air Pollution

- Sources and emission rates of pollution
- Topography: Mountains as barriers for air movement, forming temp inversion layer and promoting pollution over certain areas
- Atmospheric conditions: Temperature, cloud cover, and wind affecting the transportation or dispersion of pollutants

Potential for Urban Air Pollution

Depends on several factors:

- Rate of pollutant emissions
- Distance of air mass moving through urban air pollution source
- Speed and duration of the wind
- Height of the mixing layer

Indoor Air Pollution

- Environmental health hazards at homes and workplaces
- A variety of substances: Smoke, chemicals, microbes, and radon
- Different sources: Asbestos insulation fibers, wood products, poisonous gases—carbon monoxide and nitrogen dioxide, paint, cleaning chemicals

Waste Management

- The United States and the rest of the world face a tremendous solid waste disposal problem
- Urban waste disposal running out of space, half the cities in the United States
- Cost for landfill disposal skyrocketed, $20 billion plus industry
- Too much and too many kinds of waste produced in modern societies
- Issues about social justice and environmental justice

Integrated Waste Management

- IWM emerged in 1980s
- Including reduction, recycling, reuse, composting, landfill, and incineration
- Three Rs approach (reduction, recycle, reuse): Reducing urban refuse by 50 percent
- More notable success with recycling, but less successful with reducing waste production

Materials Management

- Combining sustainable use of materials with resources conservation
- New goal: "zero waste" known as industrial ecology through subsidies, penalties, and incentives.
- Industrial ecology: Producing natural urban and industrial ecosystem through material management, waste from one part of the system as a resource for another part

Solid Waste Disposal

Solid waste (SW)

- Primarily an urban problem
- Paper by far the most abundant solid waste
- Plastics: 60 percent increase since 1986
- Much toxic and infectious wastes: Disposed in large sanitary urban landfills

Solid Waste: Sanitary Landfills

- Defined by the American Society of Civil Engineering, emerged in 1930s
- Potential hazards: Leachate entering water system
- The concentration of pollutants in leachate much higher than in raw sewage
- Uncontrolled production and release of methane gas, growing trend in producing and selling methane as a resource

Site Selection and Design are Key

Figure 19.10

Hazardous Waste Management

- Toxic, inflammable, corrosive, chemically unstable
- ~1,000 new chemicals marketed annually
- ~50,000 chemicals currently on the market
- The United States currently generating more than 150 million metric tons of hazardous waste each year
- Uncontrolled or illegal dumping in the past

HW: Responsible Management

- Many hazardous chemical waste management options such as recycling, on-site processing, high temperature decomposition, etc.
- Surface impoundment: Monitor risk of air and water pollution
- Deep well disposal: Consider earthquake risks
- Incineration of hazardous chemical waste
- Secure landfill

Hazard Waste: Secure Landfill

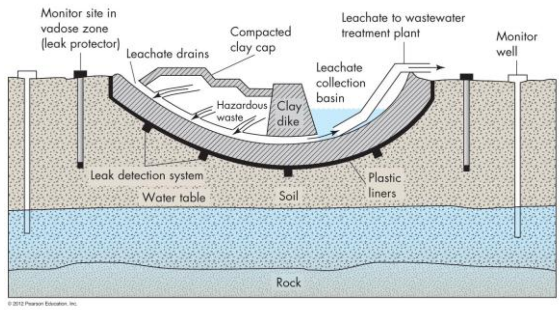


Figure 19.13

Environmental Planning: Site Selection

- Site selection: evaluation process to see if the environment supports human activities
- Set site-selection criteria: ensure site developments compatible with both the possibilities and limitations of natural environment
- Providing geologic info: crucial info on rock types, rock structure, soil properties, hydrologic characteristics, topography, and hazardous events
- Environmental engineering perspectives on testing, design, and prediction

Environmental Impact Analysis

- 1969 National Environmental Policy Act (NEPA)
- Environmental Impact Statements (EIS) for all federal actions: potential impact on the quality of the human environment
- Scoping: identifying important environmental issues to be evaluated in detail
- Mitigation: identifying action plans to avoid, lessen, or compensate for anticipated adverse environmental impacts of the project

Environmental Impact Analysis

Negative declarations:

- Filed when a particular project is viewed not to cause a significant adverse environmental impact
- Provide detailed info to support the contention of no significant negative impact on the environment
- Present a complete and comprehensive statement regarding potential environmental problems

Land Use Planning

- Conversion of agricultural lands to urban development intensifying existing urban environmental problems
- Good land-use planning essential for:
  - Sound economic development
  - Avoiding hazards and conflicts between different land uses
  - Managing land and resources efficiently
  - Maintaining a sustainable high quality of life

Land Use Planning Process

- Identify and define issues, problems, goals, and objectives
- Collect, analyze, and interpret data on hazards and resources
- Develop and test alternatives
- Formulate land use plans
- Review, adopt, and implement plans
- Revise and amend plans

Scenic Resources

- Scenery in the U.S. recognized as natural resource since 1864, when the first park is established
- Landscapes' varying degrees of scenic value recognized by general public
- Growing awareness of and concern for the scenic values of the "everyday" nonurban landscape beyond traditional views of recreation and preservation

Sequential Land Use

- Sequential land use vs. traditional permanent and exclusive land use practice
- Conform with the general principle "*The effects of land use are cumulative*"
- Responsible land use: Obligation to future generations and land reclamation after waste disposal or mining
- Reclamation of impacted land for subsequent use…

Sequential Land Use

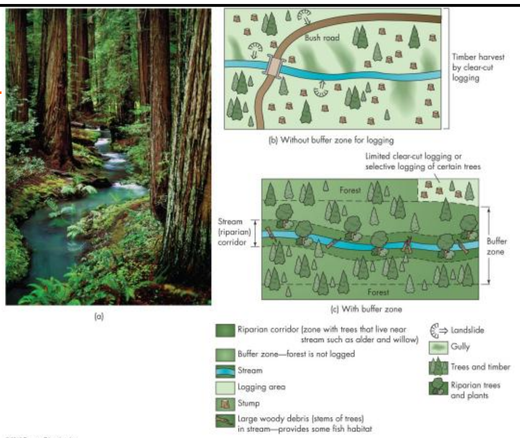
(a)

(b)

Figure 19.16

Multiple Land Use

- Use land for multiple purposes, e.g.,
  - Forests for recreation and timber harvesting
  - Reservoirs for irrigation, flood control, fishery, and recreation
- Meet the challenges of maximizing benefits for multiple land-use purposes
- Requires well-thought-out, comprehensive land-use planning



(a) (b) Without buffer zone for logging (c) With buffer zone

Environmental Law

- Important for environmental planning implementation and problem solving
- Emerging focus: emphasis on problem solving, mediation through negotiation
- The process of law: consultation, negotiation, and mediation have proven more successful than traditional confrontational and adversarial strategies
- Important to recognize the difference b/w comprehensive collaboration and simple compromise

Geology, Environment, & the Future

Avoiding an environmental crisis (Lester Brown):

- Avoid a potential food shortage for the near and intermediate term
- Control global population growth
- Conserve and sustain water resources, especially groundwater
- Control carbon emission and global warming

Attaining Sustainability for the Future

Ensuring and attaining sustainability for the future:

- Ensure renewable resources are available for future generations
- Evaluate and adjust values and lifestyles
- Set sustainable development as a global issue and priority
- Make a long-term plan: proactive prevention, rather than reactive problem solving after surprises or shocks

Critical Thinking Topics

- For the region in which you live, identify potential hazardous wastes that are produced by homes, businesses, and industry or agriculture
- Do you think the steps stated by Lester Brown are necessary to avoid an environmental crisis?
- Discuss how an environmental crisis in China would affect the global environment. What could China do to avoid some of the environmental damages of industrial growth?
- What are the critical relationships between geology, environment, and the future?